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Pasadena, California

Atmospheric Infrared Sounder

AIRS v6 Level-2 Startup State

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What It Is

- The AIRS physical retrieval works on cloud-cleared radiances.
- These radiances come from a cloud-clearing step.
- The cloud-clearing step in turn needs to start with an estimate of atmospheric T(p), q(p)
  - Use of IR in this stage raises issues of duplicate use of information content.

History

- AIRS has always used a 3-step startup process:
  - ① A step which gives a rough T(p), q(p) using only MW and/or **cloudy** radiances
  - ② An initial cloud clearing
  - ③ A regression
- Up to v4 step #1 was a MW-only optimal estimation retrieval based on a NCEP/UARS T(p), q(p) climatology
- For v5 step #1 changed to a regression that works on cloudy radiances
  - An IR-only cloudy regression was originally developed for v5 IR-only retrieval.
  - Performance was so good that an IR+MW cloudy regression was developed for the IR+MW system.

Why Revisit Startup Now?

- An improved ECMWF forecast based climatology is now available
- Some limitations of the current startup approach have emerged
  - Does not provide internal error estimates to later retrieval steps
  - Does not provide averaging kernels
  - Significant work is required for maintenance
  - Can react unpredictability to novel data:
    - Spectral shifts
    - Increasing CO2
  - Is a likely contributor to spurious trends in retrieved products
- Bill Blackwell of MIT has produced a new candidate startup algorithm: SCCNN
  - Stochastic cloud clearing
  - Neural network
  - Reported at previous science team meetings

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ECMWF-Based Climatology

- The make-up of the ECMWF forecast climatology was described in detail at the 2009-02 netmeeting
  https://airsteam.jpl.nasa.gov/netmeeting/20090226.Netmeeting/Manning_ECMWF_AIRSv5_clim.pdf

- This climatology leverages existing programs which:
  - Extract ECMWF forecast/analysis at AIRS observation locations into AIRS-compatible 100-layer products
  - Grid these products in 1x1 degree cells

Climatology Comparison

	Old	New
Spatial Resolution - Latitude	2.5 degrees (troposphere) 10 degrees (stratosphere)	1 degree
Spatial Resolution - Longitude	2.5 degrees (troposphere) 360 degrees (stratosphere)	1 degree
Temporal Resolution	1 month	1 month
Temporal Specificity	Variation within a day not modeled	Appropriate for local overpass time
Surface type	No differentiation	Land/Sea handled separately
Model	NCEP 15-year reanalysis	ECMWF forecast ~2008 with improved surface
Variance	No variance data	Has variance data

Using the New Climatology

- The new climatology could be used in several ways:
  - Input to the MW-only retrieval in the V4 architecture
  - Replace the MW-only or cloudy regression as the first stage of startup
  - Replace the entire startup
- The exercise reported next used the climatology in place of the entire startup

Exercise Description

- These runs use simulated data from UMBC for 2008-12-08
  - Surface is Masuda land & ocean
  - There are clear and cloudy radiances for the entire day
    - This is a high quality simulation
    - According to George Aumann the clouds look realistic
      - See his presentation on Wednesday
  - The truth is known
- The baseline algorithm (v5.4) is compared to the same algorithm with climatology startup replacing both regressions (v5.4Clim)
  - Both have Joel Susskind's surface improvements
  - Both are IR-only
- V5.4Clim has climatology naively "dropped in"
  - No use is made of the variance
  - No adjustments have been made to the physical retrieval
  - The climatology used for startup is based on December 2007
    - Using December 2008 would be cheating

Exercise Description

- Because QC has not been adapted for v5.4Clim, all comparisons are performed over all retrievals.
  - Yield is 100%
  - This is a preliminary proof of concept, not a robust test
- Skill is used for the comparison.
  - Skill = correl(retrieved – background, truth – background) * sqrt(yield)
  - See talk http://airs.jpl.nasa.gov/documents/science_team_meeting_archive/science_team_meeting_2008.10.14/science_team_meeting_2008.10.14_files/mannning.2008-10-18.pdf
  - Skill effectively weights cases more highly the more they diverge from a climatology background
  - The same climatology which is used as a first guess in v5.4Clim is used as a background in the skill calculation.
    - This means that if the physical retrieval passed the climatology through unaltered it would get a skill of zero.

Exercise Limitations

- The implementation of v5.4Clim was incomplete
- Only one day of data was used
- Only simulated data was used
- The lack of QC makes interpretation of results difficult.

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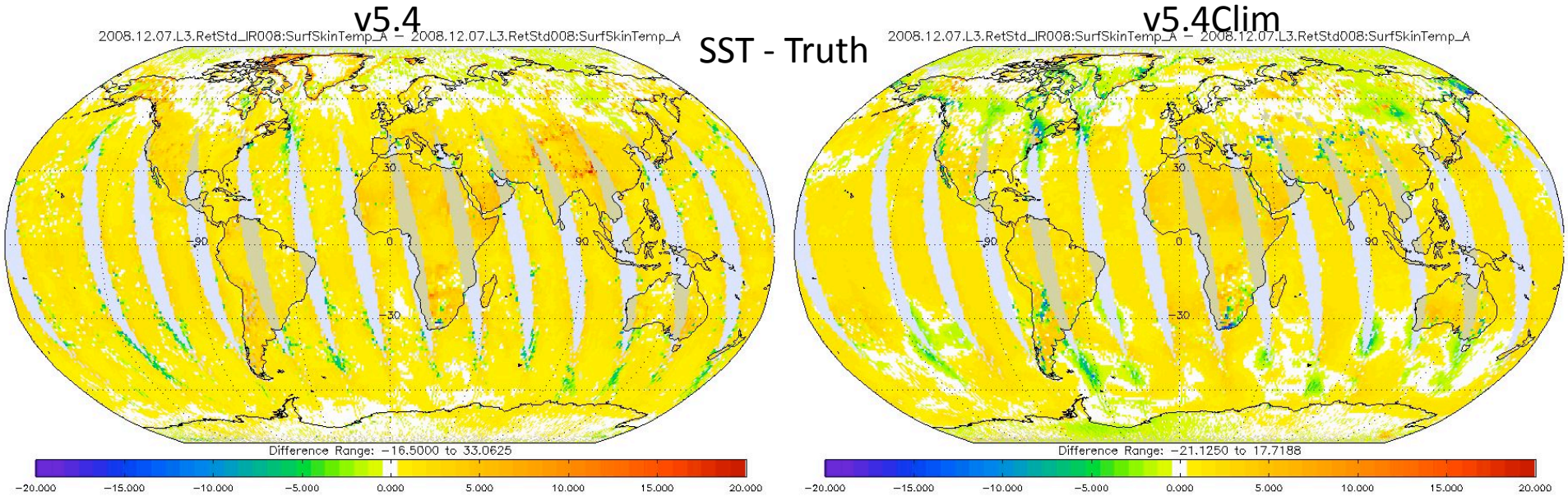
Clear Results: Ascending SST



- Results of v5.4 and v5.4Clim are comparable
  - Both have ~1 K warm bias
    - This may be due to details of the simulation (did not include optical depth tuning)
  - Both have trouble at high scan angles in very wet or dry cases
- v5.4 is noisier than v5.4Clim and has more angle dependence
- v5.4Clim has larger regions where Tsurf is biased significantly cool
  - These are dry regions relative to climatology

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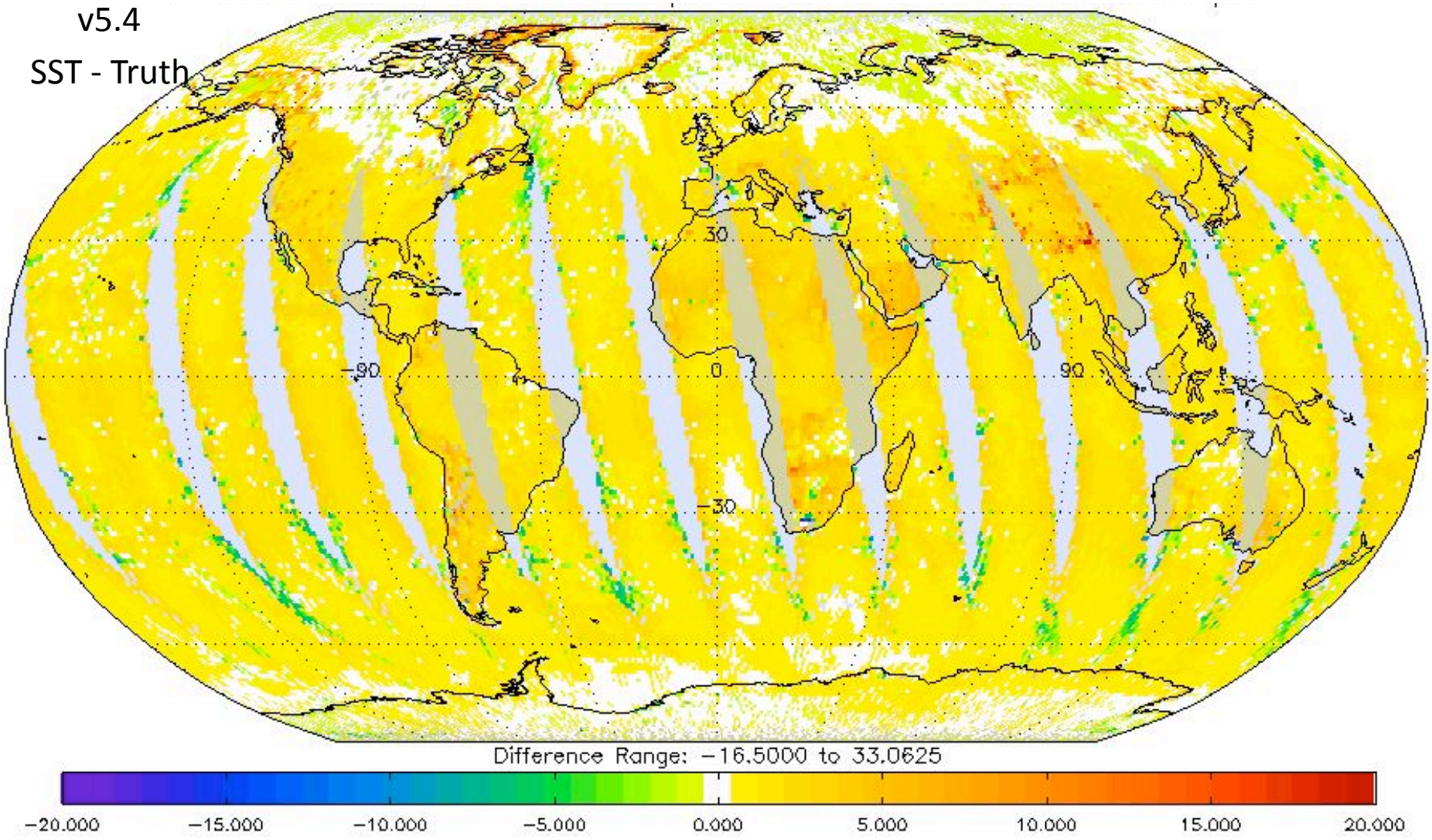
Clear Results: Ascending SST

v5.4

SST - Truth



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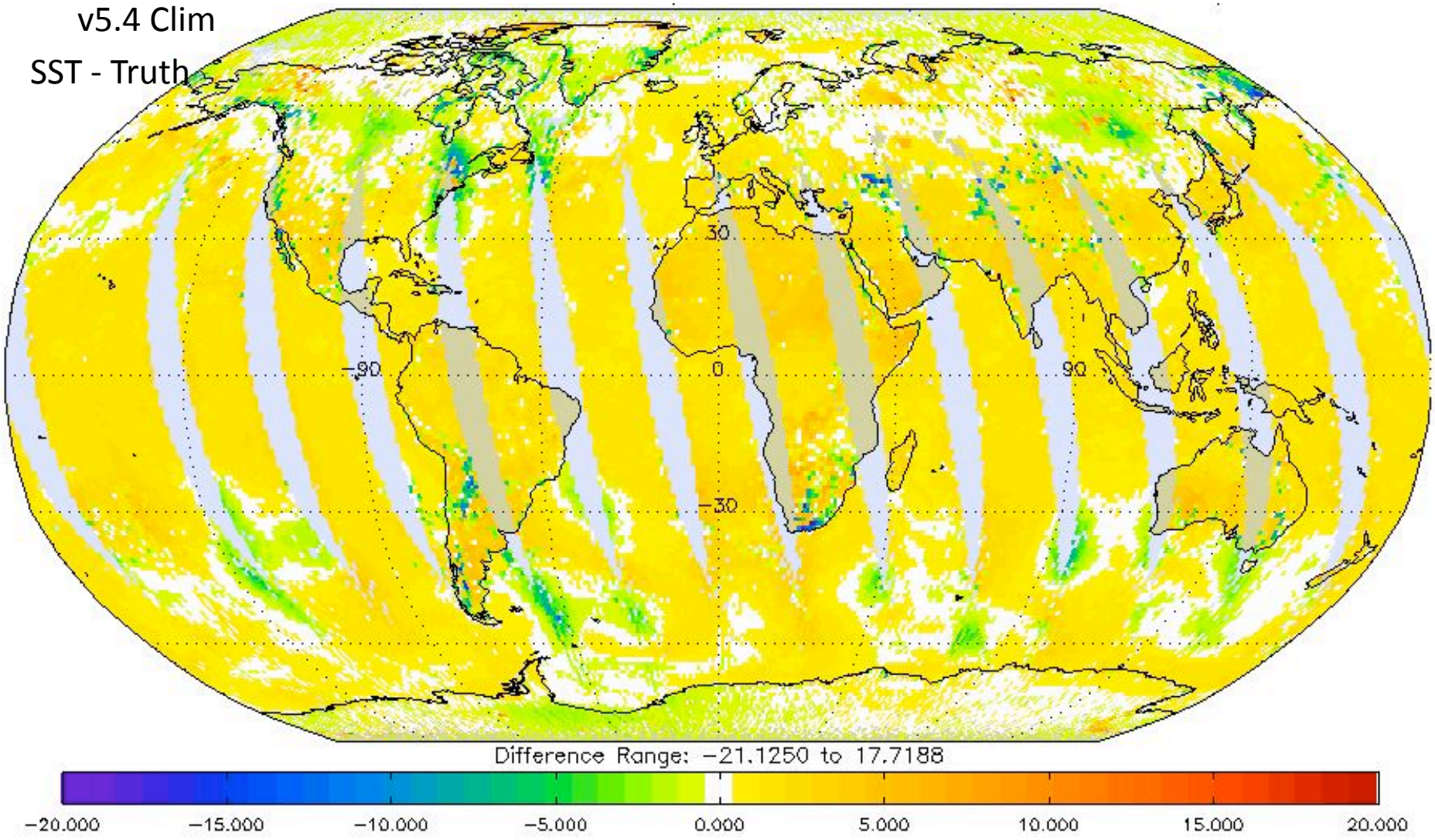
Clear Results: Ascending SST

v5.4 Clim

SST - Truth



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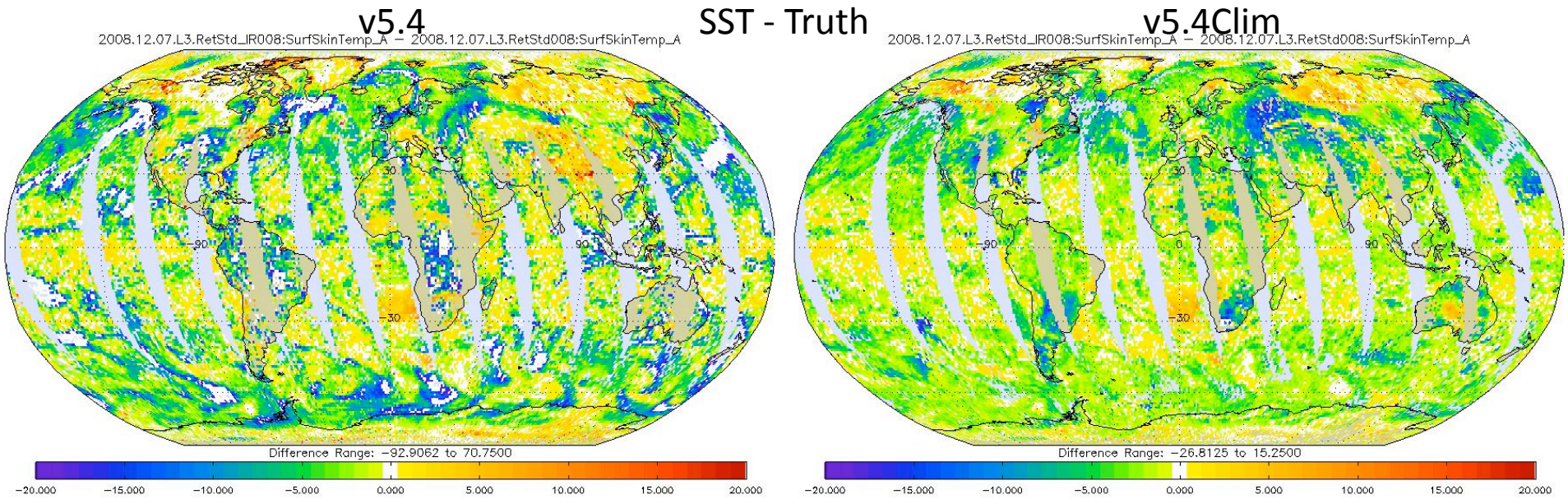
Cloudy Results: Ascending SST



- Results are similar for v5.4 & v5.4Clim
- Missed clouds are the main problem for both
  - V5.4 is more prone to run away >20K cold
    - These would normally be identified by QC
  - V5.4Clim sometimes just fails in cloud clearing for these runaway cases because the startup state is too far from the truth

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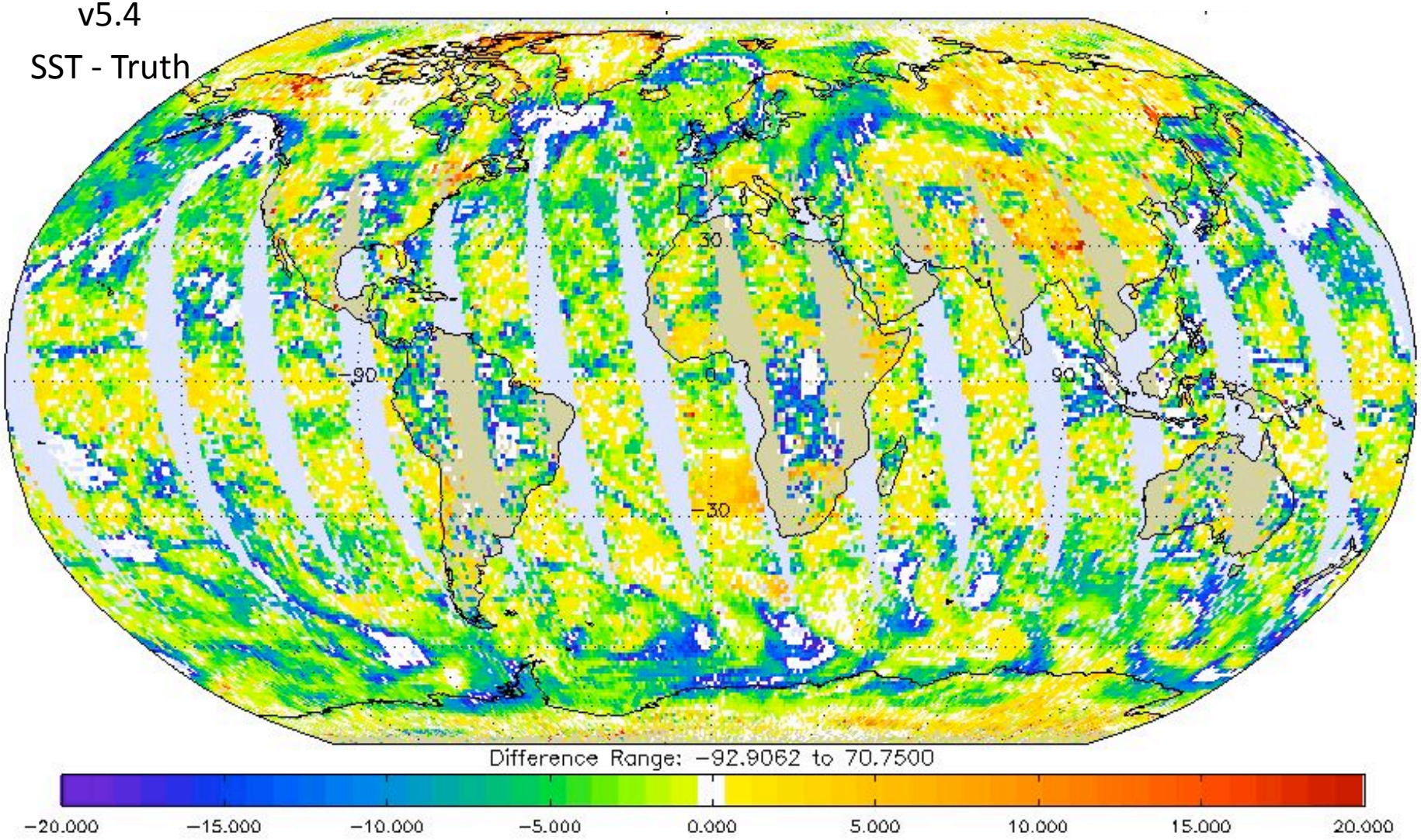
Cloudy Results: Ascending SST

v5.4

SST - Truth



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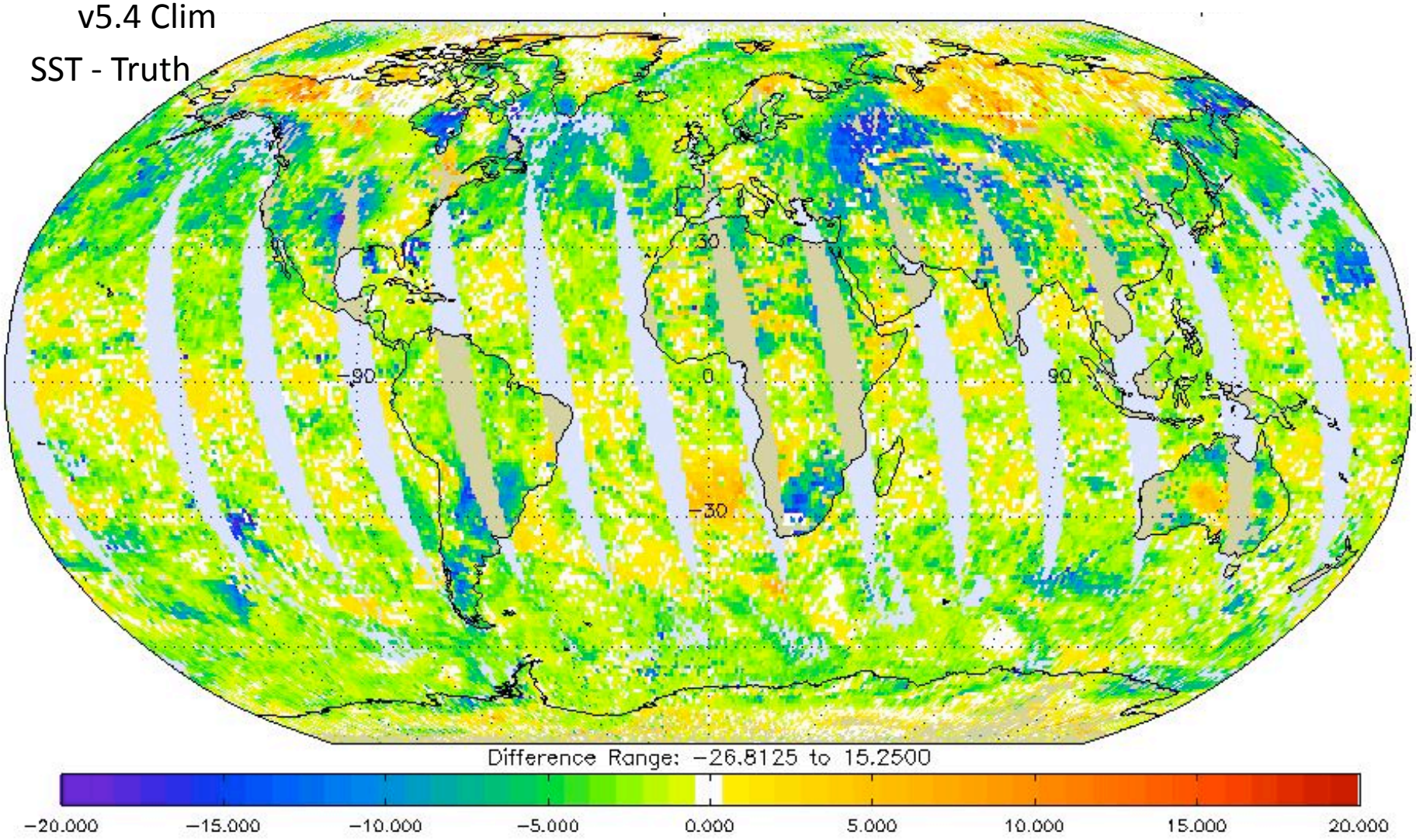
Cloudy Results: Ascending SST

v5.4 Clim

SST - Truth



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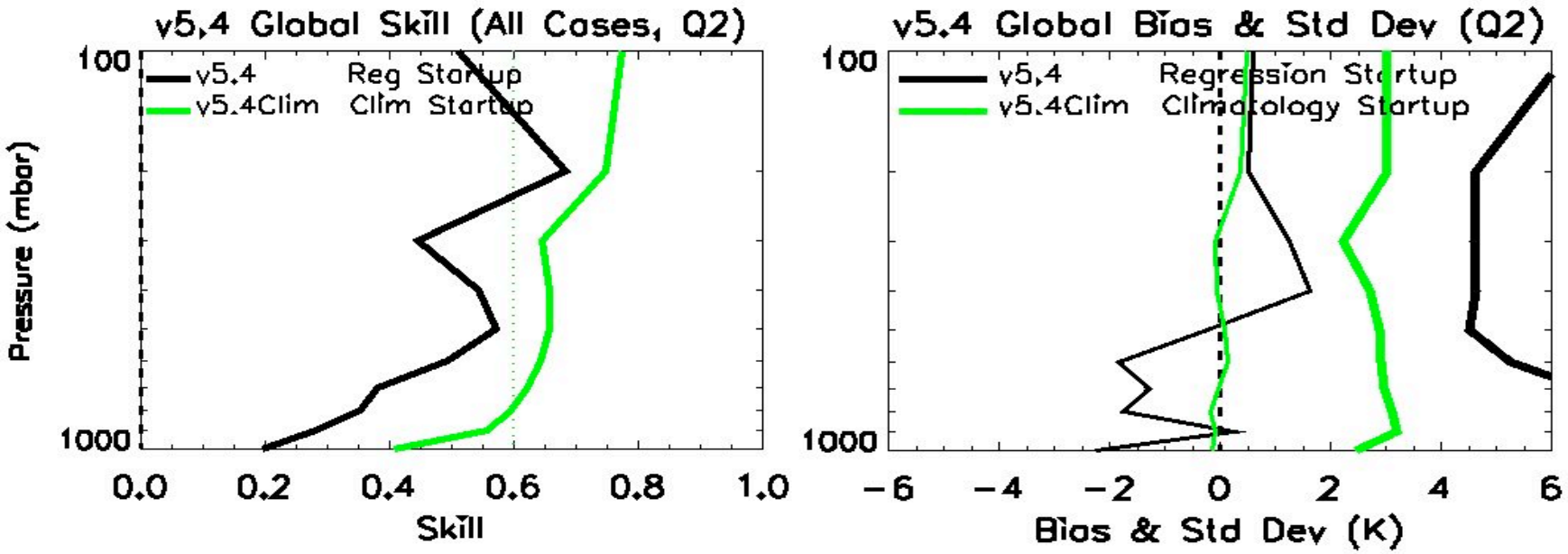
Cloudy Results: Temperature Profile Skill



- Global stats suggest v5.4Clim is superior for skill, bias, and standard deviation of temperature profile throughout the troposphere.

- The difference is greatest at the surface
  - V5.4Clim seems unaffected by problems with cloud clearing

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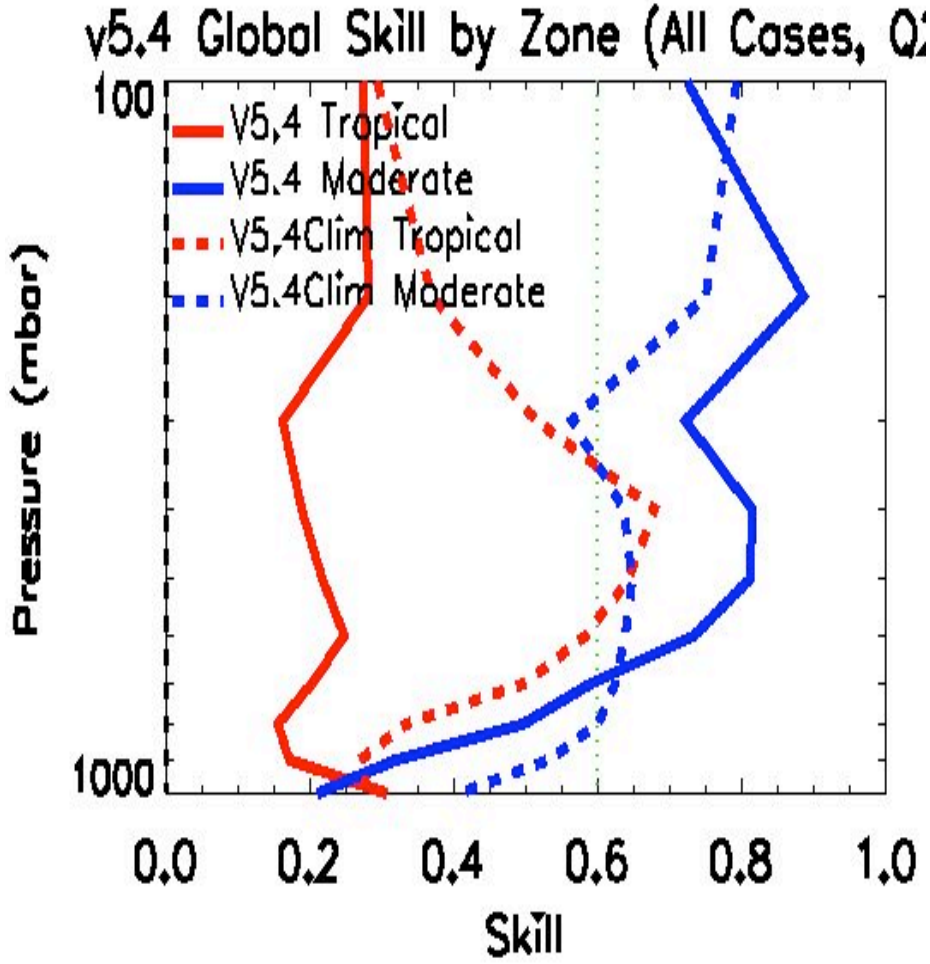
Cloudy Results: Temperature Profile Skill



- V5.4Clim seems much better than v5.4 in the tropics (+/- 20 degrees latitude) where the variation of the weather is relatively small and cloudiness is high.
- V5.4Clim seems best below 700 mbar everywhere.
- V5.4 is better in the troposphere above 700 mbar in the moderate region (40-60 degrees latitude) where the weather is more changeable
- Results for the subtropical and polar zones also favor v5.4Clim, though not as strongly as the tropics do.

Analysis: Climatology Startup

- V5.4Clim compares surprisingly well with the v5.4 baseline, even without changes to the physical retrieval
- A well-tuned system with a climatology start-up would need:
  - Substantially more channels than the baseline system
    - Because regression is currently providing all vertical fine structure
  - Substantially more vertical retrieval levels than the baseline system
    - Because the initial state is further from the final state
  - Substantially more CPU time
    - This slowdown is acceptable.

Analysis: Extreme Weather

- Extreme weather conditions are the most difficult for a system with a climatology startup
  - Cloud clearing must work reasonably with a background state far from the true state
  - The physical retrieval must make large changes
- The skill metric is specifically designed to weight non-typical weather patterns more highly
- The v5.4Clim climatology startup system already does well, even in terms of skill, compared to the v5.4 regression startup system
  - Apparently extreme weather conditions are also a problem for regression

SCCNN

- Bill Blackwell has described the algorithm at previous meetings. http://airs.jpl.nasa.gov/documents/science_team_meeting_archive/science_team_meeting_2008.04.15/science_team_meeting_2008.04.15_files/blackwell.pdf
  - Regression-like
- Last year I showed results of skill testing on SCCNN
  - Results were better than regression and almost equal to full retrieval
  - The boundary layer was the main problem area
  - Newer test data shows the boundary layer problem is overcome
- MIT has produced a FORTRAN-language version of the algorithm suitable for integration in AIRS operational Level-2 retrieval code
- Jan Gohlke has the standalone program running at JPL in preparation for integration.
  - Final debugging and validation is still in process.

Continuing Work

- Climatology needs to be completed.
  - Currently have only 6 months from 1-2 years
    - Need all 12 months
    - Need to fill in gaps in recent ECMWF forecast
  - Evaluate use of multiyear average vs. latest
- The physical retrieval must be optimized to work with climatology startup before a full comparison can be made:
  - Add channels and slabs
  - Reduce damping/increase iterations
  - Use climate variance as an error estimate on startup T(p), q(p)
- If regressions are going to continue to be used their training set needs to be updated to include more recent data
- We need to compare baseline v6 with:
  - SCCNN
  - Climatology
    - Replicate results at other locations
  - MW-Only with the new climatology

Conclusions

- Climatology startup is a viable alternative to regression.
  - More development and testing is needed
- The final choice of v6 startup should not be based only on skill or other measurements of accuracy and yield. We also must consider:
  - Predictability of results
  - Error propagation
  - Availability of averaging kernels

BACKUP

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SST v5.4 Clim – Climatology: Shows Physical Retrieval Can Make Large Changes